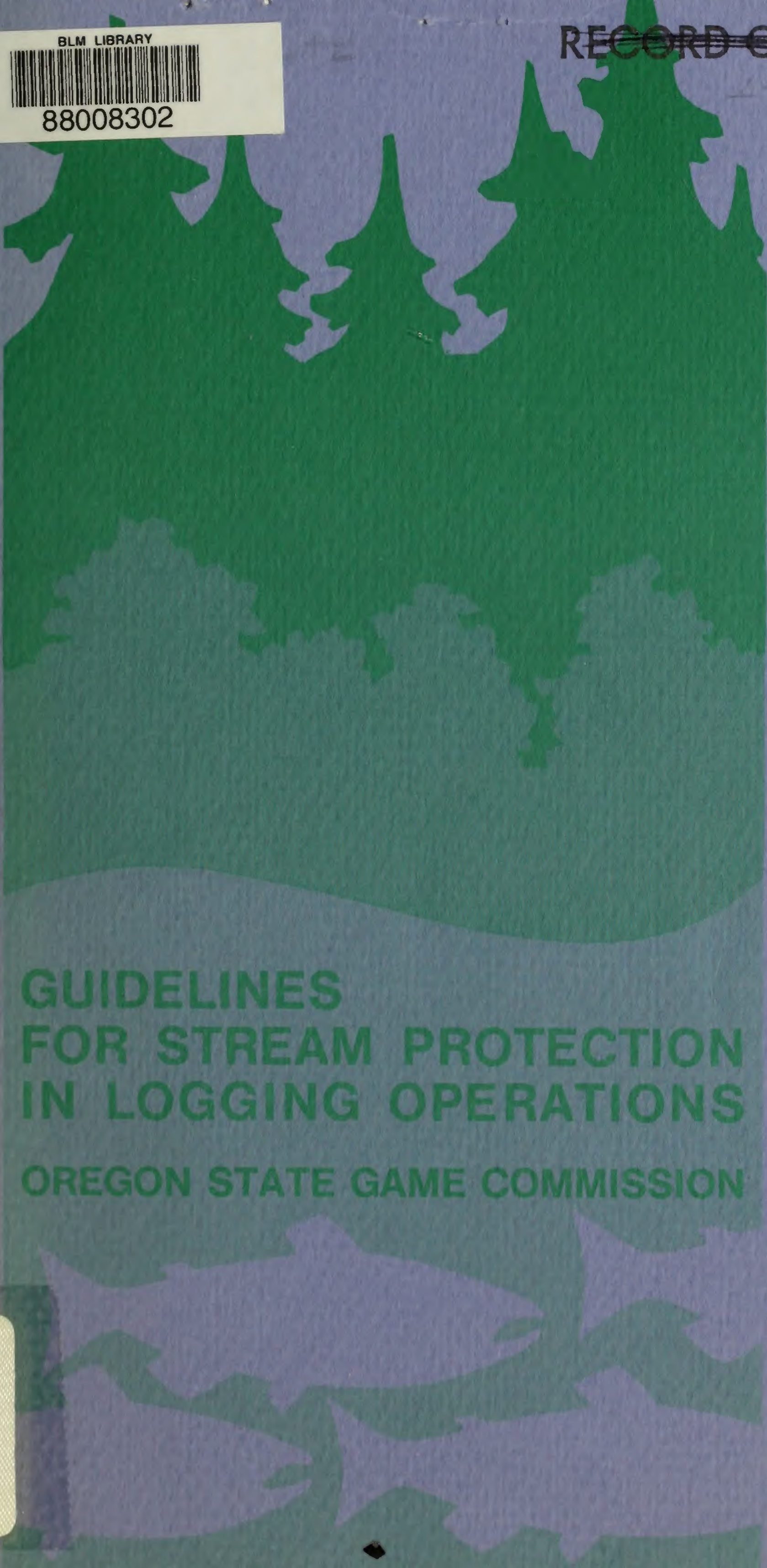

GUIDELINES FOR STREAM PROTECTION IN LOGGING OPERATIONS

OREGON STATE GAME COMMISSION

GUIDELINES FOR STREAM PROTECTION IN LOGGING OPERATIONS

By

Richard L. Lantz

A Report of the Research Division
Oregon State Game Commission

P. O. Box 3503
Portland, Oregon 97208

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The Author

Richard L. Lantz has been a project leader with the Oregon State Game Commission Research Division since 1966. He received his bachelor of science degree in wildlife management from Oregon State University and completed two years of graduate study at the University of Idaho in the School of Forestry, Wildlife, and Range Sciences. His major work has been in directing a long-term study of the effects of logging on aquatic resources. He is a member of the American Fisheries Society, the Forestry Honor Society, Xi Sigma Pi, and has been a member of the Society of American Foresters.

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Foreword

The resources produced in a watershed are interdependent and the activities of man in utilizing one resource can affect others.

Various agencies have the responsibility for these resources. Coordination and a factual basis for management are necessary if benefits are to be realized.

This publication is an attempt to outline a practical basis for the management of Oregon's coastal watersheds for the continued production of timber, fish, and high-quality water. Its main thrust, based on research results, is that forestry and fishery management need not conflict. By protecting streamside vegetation and minimizing sources of sedimentation through careful planning, these resources can be produced at the same time in the same watersheds for the benefit of man. Our agencies are working together to achieve that goal.

J. W. McKean, Director, *Oregon Game Commission*

R. W. Schoning, Director, *Oregon Fish Commission*

J. E. Schroeder, *State Forester*

Introduction

Industries based on timber and fish resources have flourished in the Pacific Northwest since pioneer days. Legends grew up around the colorful, hard-working individuals who made up the backbone of each trade. Today, both industries are still vitally important to our economy but we have more people looking more closely at the condition of our environment. Logging practices that were acceptable or overlooked in the past are more visible and no longer acceptable to a concerned public. Basically, conflicts can arise because trees and fish share the same watersheds.

The question is: Can forest lands be managed to provide necessary wood products as well as fish for commercial fishermen and an increasing number of sport fishermen? The answer is: Yes, if both resources are considered in planning, and the plans are fully implemented on the ground. It's not a case of either fish or timber. Wise use of both resources is essential.

The objective of this publication is to explain why certain logging practices in the West Coast Douglas-fir region are more desirable than others for protecting fish habitat and water quality. It will be shown that streams can be protected to a large extent by (1) keeping streamside vegetation intact, which in many cases will not need to include commercially valuable conifers, and by (2) taking precautions to eliminate or minimize soil disturbance and erosion, particularly that resulting from roads. Throughout, emphasis is on the prevention of physical changes in streams rather than on rehabilitation. Some background on the requirements of salmon and trout, and on the research results which provide a basis for this point of view, is presented. For the person interested in more detail, references are cited. Recommended practices for stream protection are summarized.

It should be emphasized that the idea here is not to tell anyone how to log, but to point out how specific water quality changes are related to specific logging practices. Once these relationships are understood the information can be applied to other areas during the planning stages of any logging operation so that detrimental changes to streams can be avoided. Foresters and loggers are best qualified to alter logging practices to protect streams. In addition, fishery biologists are willing to provide assistance in determining the type of protection needed in a given area. Such cooperation can result in better multiple-use resource management.

The Freshwater Requirements of Salmon and Trout

The West Coast Douglas-fir region supports five species of anadromous salmon and two species of anadromous trout as well as resident fish. "Resident" fish remain in freshwater all their lives, but those that are "anadromous" come as adults from the ocean into freshwater streams to spawn. Anadromous species of particular importance in Ore-

gon include coho (silver) and chinook (king) salmon, steelhead trout (as winter- and summer-run fish), and the coastal cutthroat trout (sometimes called "blueback" or "harvest trout"). Their young live in freshwater streams for at least one year before going to the ocean, and can be affected by logging operations. Therefore, it's important to protect the stream environment at all times of the year (Figure 1).

Figure 1. The larger coho (about 5 inches) has lived in a small coastal stream for a year and is migrating to the ocean. The small coho (about 1½ inches) recently emerged from the gravel and will live in freshwater for a year before they are ready to go to sea. Therefore, it is important to protect small streams at all times of the year.

Salmon and trout require a high-quality environment, preferring clean, cool, well-oxygenated streams. They lay their eggs in streambed gravels, and spawning gravel requirements are relatively critical. Gravel that does not contain fine sediments assures the best survival of eggs and fry (Figure 2). Coho and steelhead normally spawn in gravel up to about the size of chicken eggs (Figure 3). Larger fish, such as the chinook salmon, are able to use gravels up to the size of a softball. Smaller fish, such as the cutthroat trout, use smaller gravels.

Adults move onto the gravel beds during the fall and winter when streamflows are high. The female chooses a site for spawning, periodically turns on her side, vigorously arches her body, and loosens the gravel with her body and tail movements. Soon she has completed digging a spawning nest, called a "redd." Once the nest is ready, spawn-

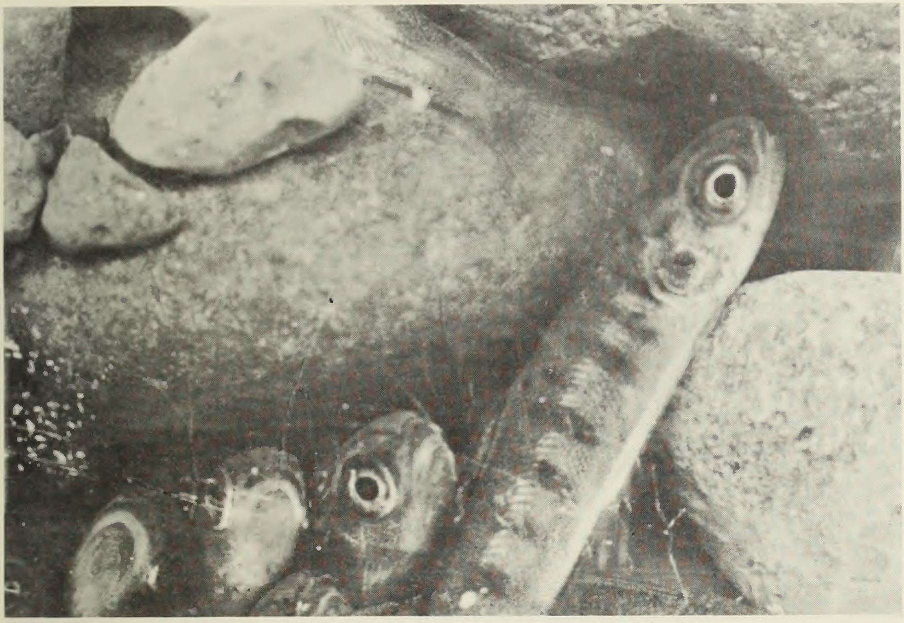

Figure 2. Clean gravel that does not contain fine sediment results in the best survival of eggs and fry (above).
Sediment can affect fish in many ways, one of which is illustrated below. Sediment has filled in the gravel where young coho salmon, 1½ inches long, were developing. When the time came to move out of the gravel and into the stream to feed, the fish were trapped and died.

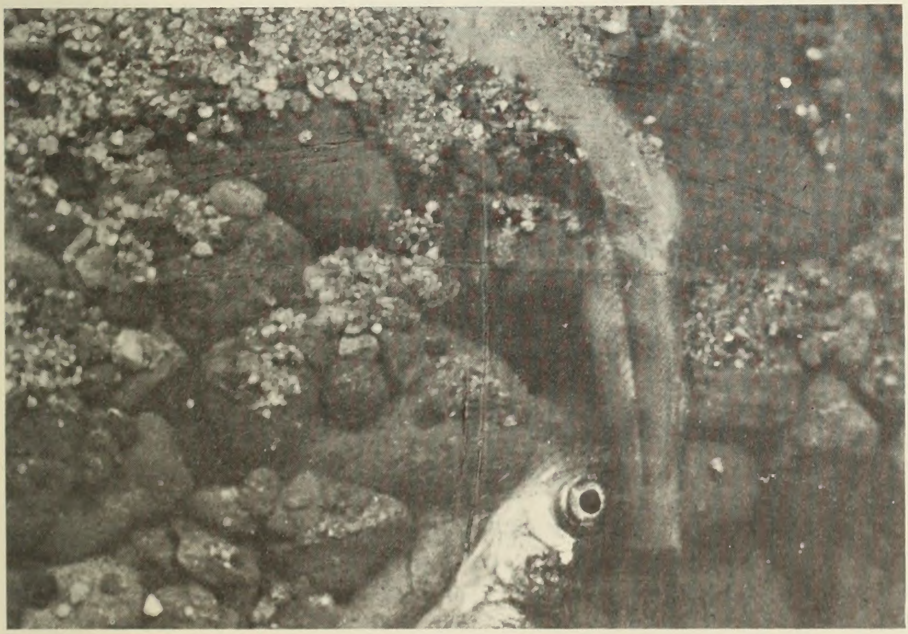

Figure 3. Good spawning gravel for coho salmon.

ing can take place. A male, who has been near the female while she dug the spawning nest, fertilizes the eggs as they are deposited into the "redd." After spawning, the female moves slightly upstream and dislodges gravel onto the eggs. Coho usually cover their eggs with about ten inches of gravel. The eggs hatch and the small fish absorb their yolk sacs in approximately three months in Oregon coastal streams. Then the fry move out of the gravel into the stream to live and grow before going to the ocean to mature and return as spawning adults. All Pacific salmon die shortly after spawning, but trout can survive and return to spawn more than once.

Small Streams Are Important

In the Pacific Northwest, small streams are important producers of salmon and trout (Figure 4). In fact, streambeds that are dry in the summer can be major spawning tributaries for salmon and trout in the fall and winter. For example, in the Rogue River system, most of the tributaries used by summer steelhead for spawning during winter are dry or intermittent in the summer. The young steelhead leave the tributaries in the spring shortly after emerging from the gravel, and move into larger streams.

A stream can be defined, in terms of its importance to the fishery, only by a knowledge of the fish species present. In the past, attempts to define streams on the basis of other criteria have resulted in a lack of protection for important streams. The importance of a particular stream

Figure 4. Small streams, such as the one shown above, can be important spawning and rearing areas for salmon and trout and should be protected. Even streambeds that are dry in the summer can be major spawning tributaries for salmon and trout in the fall and winter when streamflows are high.

can be determined by contact with the local district fishery biologist. The impact of upstream activities on downstream areas must also be considered.

In many cases, small headwater streams contain most of the spawning gravel found in large river systems. Except for a few fisheries, the bulk of the Pacific Coast catch of salmon and trout is the result of natural reproduction from these upstream watersheds, the majority of which are forested to some extent. Conflicts can arise because such streams look insignificant in the late spring and summer when many logging operations are underway, but the same streams look different in the fall and winter when adult fish are moving upstream through high water to spawn. Protection of such streams is vital to the production of salmon and trout.

Natural Spawning Areas Provide Most of Our Fish

Most of Oregon's salmon and trout production comes from nature. Since much of the spawning gravel for an entire river system often occurs in extremely small headwater streams or in a few restricted areas, it can possess a high dollar value in terms of the fish produced. For example, fall chinook in California's Battle Creek spawn in a 4.5-mile section of stream. The fish produced have a value to the sport and

commercial fishery of $350,000 annually per acre of spawning gravel. Most of the sockeye salmon production in the Fraser River in British Columbia comes from about 300 acres of spawning area. With the annual commercial catch valued as high as fifty million dollars, each acre is capable of producing salmon annually valued at more than $160,000. Closer to home, similar situations exist in Oregon. Another way to look at the value of natural spawning areas is to examine the cost of building artificial spawning channels, which, on the West Coast, has ranged from $120,000 to $470,000 per acre not including maintenance costs.

Hatcheries supplement natural production and play an important role in fishery management, but they have not replaced natural production. Maintaining a hatchery involves many costs that are not present when fish spawn and rear under natural conditions. In addition, good hatchery sites in terms of available high-quality water supplies are limited. Therefore, the future of the majority of Oregon's salmon and trout resource depends on how our streams are protected.

Streams Are Public Resources

Streams, and the fish in them, belong to the public regardless of who owns the adjacent land. When logging activities affect a stream, resources that belong to all of the people of Oregon are affected.

Laws exist that protect fish and the water quality of streams. The 1967 session of the Oregon legislature authorized the State Sanitary Authority (now the Department of Environmental Quality) to formulate water quality standards. The General Water Quality Standards developed since then establish specific limits below which Oregon's water will not be degraded, and provide for fines of up to $1,000 or one year in the county jail or both for each day of violation (O.R.S. 449.990). Special standards supercede general standards and have been developed for some Oregon rivers. It is also important to note that our water quality laws contain a non-degradation clause (Section 11-010) which says that the highest and best practicable treatment and control will be utilized. In other words, emphasis will be on preventing water quality changes and maintaining a quality environment rather than on attempting to correct problems already created.

Other Oregon statutes are also concerned with maintaining water quality. Pollution is defined to include, among other things, changes in temperature, taste, color, turbidity, silt, or odor of the waters . . . which will tend to render such waters harmful, detrimental or injurious to . . . wildlife, fish, or other aquatic life or the habitat thereof (O.R.S. 449.075). Water pollution is prohibited (O.R.S. 449.079), and restrictions on placing trees, brush, logs, or drift in streams are specifically mentioned (O.R.S. 164.820). The latter statute provides for a fine of up to $500 for each violation when debris is placed in a stream and not promptly removed.

Of importance to fish and the timber industry are standards relating to stream temperature, dissolved oxygen levels in surface waters, and suspended sediment loads. Oregon's General Water Quality Standards state that water temperature changes cannot exceed 2°F. in any case, and where temperatures are already 64°F. or above no change is allowed. Dissolved oxygen levels cannot be reduced below six parts per million. On those streams where turbidity standards apply, suspended sediment loads cannot be increased above natural background levels (i.e., the level upstream from the activity causing concern) when the background is less than thirty Jackson turbidity units (J.T.U.).[1] When the background level is above 30 J.T.U. a 10 percent increase is allowed. Jackson turbidity units are a visual measure of suspended sediments now accepted as the standard in Oregon. Changes exceeding such standards have been known to occur after logging has taken place in a watershed. All of the changes can affect fish populations.

Logging Can Affect Streams

The Alsea Watershed Study, a long-term research program on the Oregon coast near Toledo, provides evidence of the effects of logging operations on fishery resources and water quality in the Douglas-fir region. Clearcutting of an entire watershed (Needle Branch—175 acres) where no streamside vegetation was left is being compared to clearcutting in patches on a larger watershed (Deer Creek—750 acres) where about 30 percent of the area was harvested and vegetation was left along the stream (Figure 5). The third watershed (Flynn Creek—500 acres) will remain as an unlogged "control" unit. A control stream is needed to insure that any changes observed are due to logging activities and not to natural variation. Pre-logging studies began in 1958, access roads were constructed in 1965, and logging took place in 1966.

These headwater streams are all relatively small, with minimal summer streamflows ranging from 0.01 to 0.2 cubic feet per second (cfs). For perspective, 0.01 cfs is slightly over four gallons per minute or about the flow one could get from a garden hose, and yet the stream has supported an average spawning population of almost 60 adult coho salmon each winter in the half-mile of stream available to them.

After logging took place, major changes in the stream draining the entirely-clearcut watershed were documented. By comparison, changes that occurred in the stream draining the patch-cut watershed have been relatively minor. An exception was sediment movement from a landslide in the patch-cut watershed. The primary changes noted following logging in the Needle Branch watershed included:

1) A decrease in dissolved oxygen content of surface waters during the summer when logging debris was in the stream.

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[1] Studies on the Rogue River have shown that winter steelhead fishermen quit coastal rivers in disgust somewhere between 25 and 30 J.T.U.

Oregon State University photo

Figure 5. On the Alsea Watershed Study, the effects of clearcutting an entire watershed without leaving vegetation along the stream (above) is being compared to clearcutting in patches on a watershed where vegetation was left between the stream and the logging unit. (See aerial view of one unit—bottom photo. The stream channel is shown by a dotted line.)

Oregon State University photo

2) A decrease in dissolved oxygen levels in the water flowing through the gravel during the time that salmon and trout eggs were hatching and developing.

3) An increase in stream temperatures.

4) An increase in suspended sediment loads.

5) A decrease in the cutthroat trout population.

Cutthroat trout decreased to about one-fourth of their pre-logging numbers, from about 265 to 65 fish in a half-mile of stream, during the summer that the watershed was being logged. The trout population has not returned to average pre-logging levels to date, four years after logging. The population sampled includes juveniles that will go to the ocean and later return.

In contrast, coho populations appear to be more resilient under the conditions encountered. Coho juveniles have survived and migrated to the ocean, but those moving from Needle Branch to the ocean after logging leave earlier and are in poorer physical condition than occurred before logging. Similar changes have not been observed in either of the other two study streams. The significance of such changes cannot yet be fully evaluated, but future adult runs might provide an answer.

Streams Can Be Protected

The four physical changes that occurred in the stream environment following logging of the Needle Branch watershed could have been avoided.

As mentioned earlier, streams can be protected to a large extent by (1) keeping streamside vegetation intact, and by (2) taking precautions to minimize soil disturbance and erosion. For example, dissolved oxygen decreases in surface waters would not have occurred if logging debris had been kept out of the stream; or the decreases could have been minimized by clearing the stream while logging was underway. By not yarding logs through or falling logs into the stream, the decrease in dissolved oxygen levels in water flowing through the streambed gravel could have been eliminated. Keeping streamside vegetation intact would have shaded the stream and minimized water temperature increases. In addition, maintaining streamside vegetation requires care in falling and yarding away from the stream, and reduces stream clearance needs and dissolved oxygen problems. Sediment increases can be reduced in some cases by an undisturbed duff layer bordering the stream, but for the most part in Oregon the problem must be solved by using other approaches, such as more careful planning for and construction of roads and landings. The land management implications of these stream changes will be discussed in more detail in the following sections.

Surface dissolved oxygen levels and logging debris

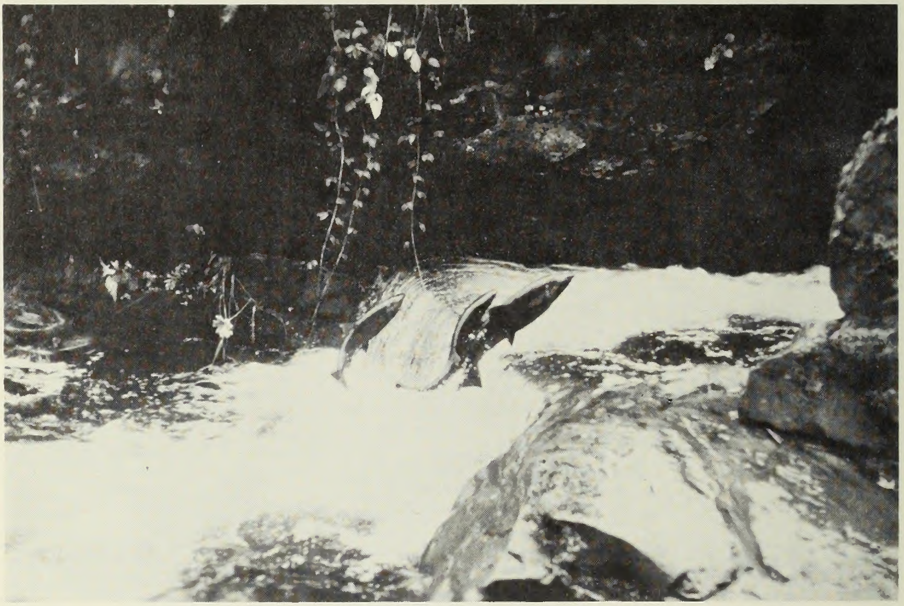
Surface dissolved oxygen simply refers to the amount of oxygen available in the surface waters of a stream. Oxygen dissolved in water is as essential for fish life as oxygen in the air is for humans. Dissolved oxygen levels less than one part per million were recorded in Needle Branch during the summer that logging occurred, and low levels persisted for several weeks in about one-third of the stream available to salmon and trout. Juvenile coho salmon placed in this portion of the stream quickly showed stress symptoms and died. Fish were able to survive above and below the area of oxygen depletion. A substantial improvement in the oxygen content of the surface waters was noticed after debris was cleared from Needle Branch in mid-September. Oxygen returned to approximately pre-logging levels by November with the advent of the higher streamflows. Surface dissolved oxygen levels since that time have remained high, and are comparable to levels in the stream draining the unlogged watershed.

The dissolved oxygen decrease in Needle Branch could have been avoided if logs and logging debris had been kept out of the stream at all times. Logging debris ponded the stream and it could not re-oxygenate itself by flowing over riffles (Figure 6). Every effort should be made to keep all debris out of the stream in order to provide access to spawning grounds for adults (Figure 7), to keep migration routes open for juveniles that are moving to the ocean, and to maintain adequate oxygen levels.

There are good and bad ways to clean out a stream. Method and timing are important. Clearance should not be done by running heavy equipment through the stream (Figure 8), creating a channeled sluiceway, removing spawning gravel, and perhaps killing eggs in the gravel or small fish in the stream. The men on the ground doing the job must understand why debris should be kept out of the stream. This is a matter of better supervision since improper stream clearance has been a large problem in the past, and continues to be so in some areas. Consultation with the local fishery biologist can be important in determining what material should be removed. In some cases he can save the logging operator money by recommending that stabilized material in the stream channel be left to provide fish habitat.

When dealing with such small but important headwaters, stream clearance is not an expensive part of the entire operation. For example, most of the stream clearance on Needle Branch was done by hand and no heavy equipment was used in the streambed. Clearing one-half mile of stream required only about ten man-days of effort; a minor part of the cost of logging a 175-acre watershed. In addition, directional falling to keep trees out of streams will reduce stream clearance costs. Keeping logging debris out of streams is also important to forest managers in terms of preventing future damage to downstream roads, bridges, and culverts. In this case, then, as in many other instances, the objectives of responsible forest and fishery managers require using the same

Figure 6. Logging debris in Needle Branch ponded the stream and kept it from flowing over riffles and re-oxygenating itself (above). Fish could not live in this section of stream for more than a few minutes because of low dissolved oxygen levels. After stream clearance (below) a substantial improvement in the oxygen content of the surface waters was observed. Clearing a half-mile of stream was a minor part of the cost of logging the 175-acre watershed. The best practice would have been to keep debris out of the stream channel in the first place, which would have eliminated stream clearance costs and water quality changes entirely.



U.S. Forest Service photo

Figure 7. Coho salmon move upstream to spawn (above). Log jams can be a barrier to adults and obstruct access to spawning grounds (below).

U.S. Forest Service photo

Figure 8. Stream clearance should not be done by using heavy equipment in the stream.

land management practices. The old adage about an ounce of prevention being worth a pound of cure applies here. It is best not to get any material into the stream in the first place.

Subgravel dissolved oxygen in relation to yarding and falling

Salmon and trout eggs need adequate dissolved oxygen in water flowing through gravel in order to hatch and develop. A substantial reduction of dissolved oxygen in the water flowing through gravel was documented after logging occurred on the Needle Branch watershed. The oxygen decrease occurred during the time that eggs and young salmon and trout were developing in the gravel. Oxygen levels in the subgravel waters have remained low for at least four years after logging. There were no comparable changes in Deer or Flynn creeks.

A decrease in subgravel dissolved oxygen levels can be associated with increases in the amount of organic and inorganic debris in the gravel environment following logging (Figure 9). In practical terms, this means that yarding through a stream or felling timber into a stream should not be permitted. Such practices break down streambanks and streamside vegetation, and deposit bark, needles, and twigs in the streambed.

For fish habitat protection, trees should be felled and yarded away from the stream channel. In steep terrain with V-notch canyons it might be necessary to leave streamside trees, especially those leaning over the stream, or to cut high stumps near the stream to keep material out

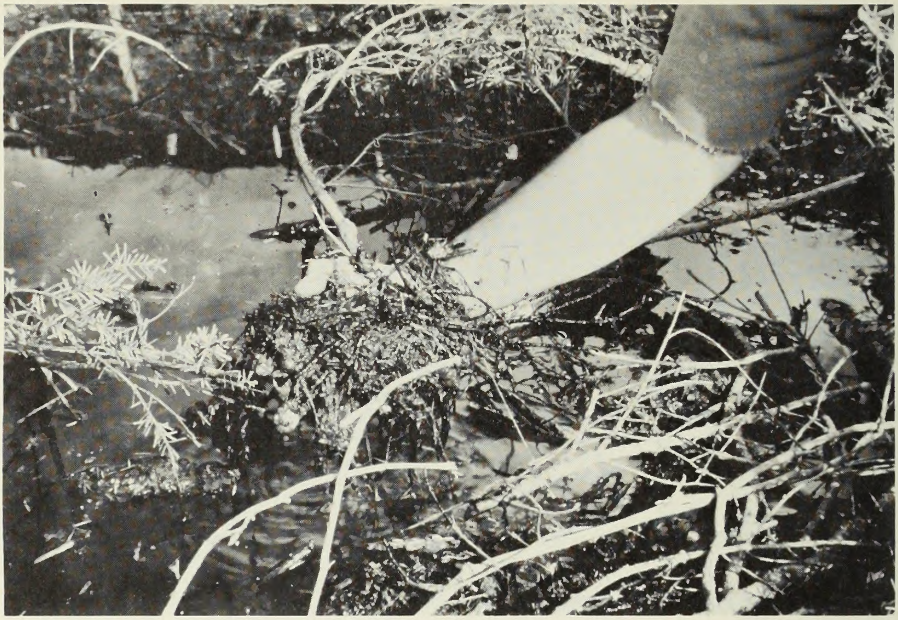


Figure 9. Falling trees into the stream channel deposits material in the streambed. Yarding through streams breaks down streambanks, and knocks down streamside vegetation. The organic debris and sediment brought into the gravel environment can result in a decrease in subgravel dissolved oxygen levels. Trees should be felled and yarded away from streams.

of the channel. Because of the fan-shaped pattern of skidtrails characteristic of high-lead systems, uphill yarding tends to disperse the flow of surface runoff; downhill yarding tends to concentrate it where sediment is more likely to reach the stream. Skyline yarding or other modified cable systems which lift logs clear of the ground should be used if logs must be yarded across a stream or if there is the possibility of serious soil disturbance by other yarding methods. Cat-yarding should be limited to flat or gentle topography, when soils are not wet, and with skidroads along the contour wherever possible. In most cases, given an equally skilled and informed operator, skyline yarding would be preferable to high-lead yarding, which would be preferable to cat-yarding in terms of soil disturbance in the watershed and stream protection.

Streamside vegetation and water temperature

Salmon and trout are coldwater animals and their body temperature is normally about the same as that of their environment. Stream temperature increases can affect salmon and trout populations in numerous ways, many of which are detrimental. For example, high temperatures can kill salmon and trout directly, increase the virulence of many fish diseases, provide a habitat that favors such fish as dace and suckers, inhibit spawning activity or block spawning runs into a stream,

affect the quantity of food available, and alter the feeding activity and body metabolism of fish. Therefore, temperature can influence the productivity of a stream by affecting the number of fish present, the species present, and their physical condition.

Water temperature increases are caused primarily by increased exposure of a stream to the sun's rays as a result of removing streamside vegetation. Thus, the shade provided by streamside vegetation is the most important factor influencing changes in water temperature over which the land manager has some control. For example, the Alsea Watershed Study streams had similar water temperatures for a number of years before logging occurred, with 61°F. being the highest temperature recorded on Needle Branch. After logging, the maximum recorded temperature on Needle Branch was more than 85°F., a 24°F. increase. Daily (24-hour) fluctuations as high as 29°F. have been recorded on Needle Branch after logging compared with pre-logging fluctuations of 1 to 4°F. Water temperature increases can be substantial as early as May, while young fish are still in the gravel. Maximum water temperatures experienced on Needle Branch have decreased each year since 1967 because of shade provided by young red alder growing along the stream (Figure 10). Such a rapid rate of revegetation does not occur in many areas, emphasizing the need for protection of existing streamside vegetation (Figure 11). Temperature changes of the magnitude occurring on Needle Branch did not appear on Deer Creek where vegetation was left between the stream and the clearcut units.

Figure 10. Young alder revegetated the streambanks on Needle Branch following logging, shaded the stream, and reduced water temperature increases; but the temperature has not returned to pre-logging levels after four years. The trees shown are three years old and up to 15 feet tall. Such a rapid rate of revegetation is not the case in many areas. Therefore, leaving undisturbed vegetation along the stream is an important land management tool.

Figure 11. The stream has been protected from logging by leaving red alder and shrubs between it and the clearcut, which borders the alder shown in the background. No commercial conifers were left in this area because they could be removed without damaging the stream. Protecting streamside vegetation will minimize or eliminate three of the four major stream habitat changes associated with logging on the Needle Branch watershed.

Canopies of vegetation should remain along the stream in all logging operations where fish and water quality considerations are involved or can be affected in downstream areas. A relatively narrow vegetation zone can often provide the shade needed for fish habitat protection. It is not necessary to leave commercial conifers along the stream if shade can be provided by shrubs and other less valuable species, and if the conifers can be removed without damaging or destroying streamside vegetation. On small streams, shrubs might be adequate to provide shade to the stream; on intermediate-sized or larger streams, hardwood trees such as alder might do the job. In some areas commercial conifers will have to remain to protect other watershed values or await technological development of timber removal methods that can protect these values.

An argument sometimes advanced against leaving trees along a stream is that they are subject to increased blowdown problems. This can be true in local areas, but it's not always the case. For example, on the Alsea Watershed Study there was no more blowdown in the timber left along Deer Creek than occurred along the stream in the unlogged watershed. Also, if the vegetative canopy is composed of shrubby species no blowdown problem exists.

Streamside vegetation protects streams in many ways

A policy that requires leaving streamside vegetation intact would eliminate or minimize three of the four major stream habitat changes associated with logging on the Needle Branch watershed. The vegeta-

tion would provide shade to the stream and reduce water temperature increases. In addition, maintaining streamside vegetation requires falling and yarding timber away from the stream and its bordering vegetation, which will then reduce stream clearance needs and dissolved oxygen problems in surface and subgravel waters. Essentially, leaving streamside vegetation intact represents a recognition of the protection needed for watershed values other than timber, and practical efforts on the ground to provide that protection and avoid the stream.

From an economic standpoint, fishery values can often equal or exceed the value of commercial Douglas-fir left within 100 feet on either side of a stream. This was the conclusion reached in a recent technical report prepared by the Bureau of Land Management whose current directives require leaving vegetation along all streams having fishery values. Since, in many cases, commercial conifers do not have to remain along a stream to protect it, there can be little argument against leaving streamside vegetation as a practical watershed and land-management tool.

Sediment in streams

Increased sediment loads in streams can have detrimental effects on fish, their habitat, and their food. Sediment can also affect local economies that rely on water-oriented recreational uses, since "muddy" stream conditions seriously disrupt sport fishing and angler success. The downstream effects of sediments must also be considered in any logging operation because poor practices on one relatively small area can have an impact for miles downstream.

Although erosion occurs in undisturbed watersheds, man's activities in a watershed usually accelerate erosion and increase sediment levels when compared to undisturbed areas. Roads and road construction activities are significant sources of sediment. Erosion from landings, yarding activities, and slash-burning can also contribute to increased sedimentation.

On the Alsea Watershed Study, roads in both logged watersheds have been major contributors to an increase in suspended sediment levels in the streams. They acted either by (1) causing headwall slumps or landslides from sidecast materials (Figure 12), or (2) by intercepting natural drainage patterns and increasing erosion along the roadbed. Since often one of the long-term objectives of logging road construction is to provide access for fire control, road failures are another example where forestry and fishery management goals should be the same. Roads that have been eroded and become impassable do not provide fire control access, and also contribute sediments to streams. Therefore, practices that control sediment problems should be incorporated into every logging plan and implemented on the ground (Figure 13). Soil disturbance should be minimized (Figure 14). It may not yet be technologically feasible to construct roads in high-hazard slump areas. Here it is important to note that some yarding methods, such as the skyline system, require the use of less roads than do other methods.

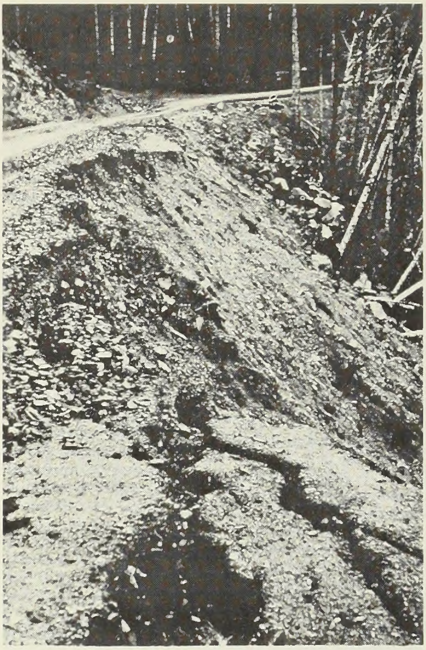
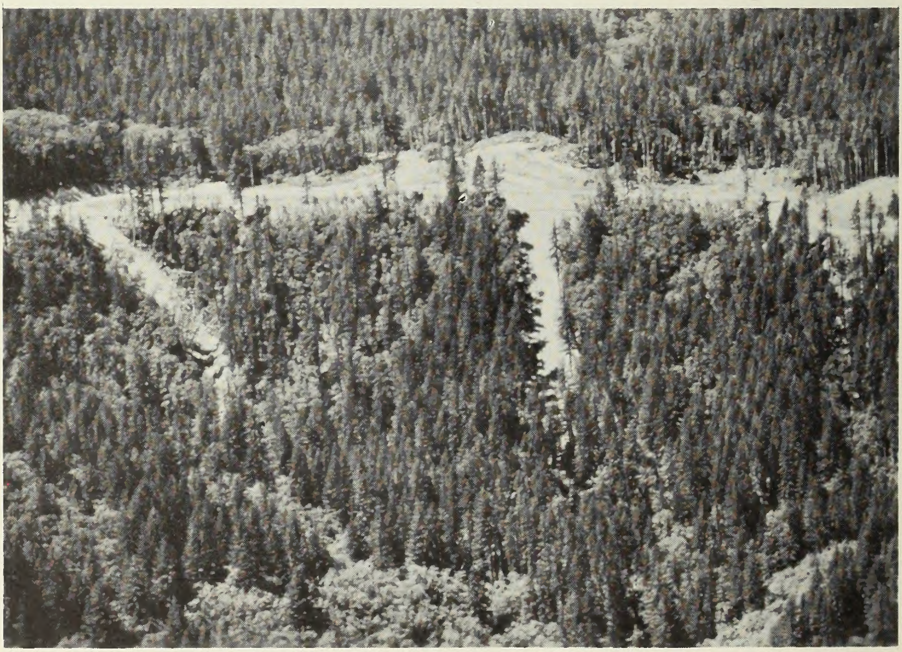
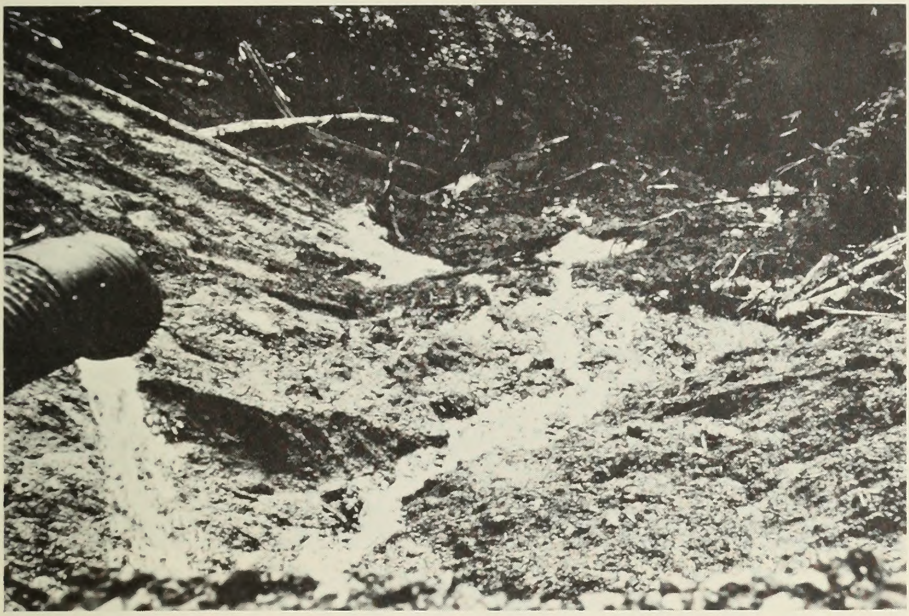


Figure 12. Roads are major contributors to increased sedimentation in streams. Improperly compacted sidecast material has slumped into the watershed.





U.S. Forest Service photo

Figure 13. Poorly placed culverts can result in increased sediment loads in a watershed (above). Better planning can decrease such problems by extending the culvert with half-round until the water is draining on stable material (below). Culverts can also effectively block anadromous fish runs if improperly installed.

Oregon Forestry Dept. photo

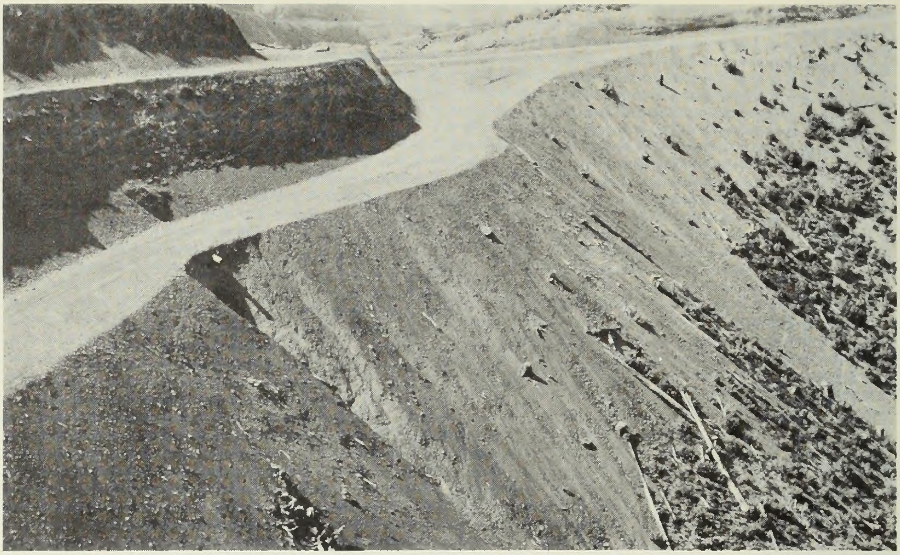
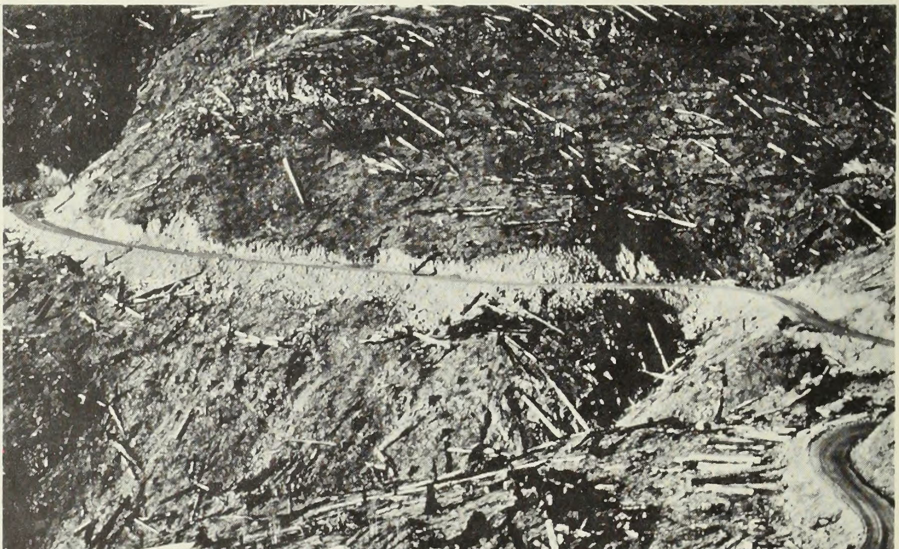


Figure 14. A road that is wider than necessary results in excessive sidecast material (above). The area covered by the sidecast is not producing timber and is also causing increased sedimentation downstream. Below is a narrower road that is sufficient for logging access, less expensive to construct and maintain than the road above, and which has resulted in less sidecast material being displaced. It is possible to eliminate much of the sedimentation that results from roads through careful planning that takes into account all the resources involved in a watershed and minimizes soil disturbance.

Oregon Forestry Dept. photo



Summary and Recommended Practices for Stream Protection

Guidelines for protection of fish habitat and water quality in logging operations have been developed as a result of the Alsea watershed research program and related studies. They include the following:

1. Extremely small headwater streams can be important spawning and rearing areas for salmon and trout and need protection. Even streambeds that are dry in the summer can be valuable spawning tributaries at other times of the year. Also, logging activities in headwaters can affect downstream areas.

2. A formal procedure for reviewing timber harvest operations, in the planning stages as well as during logging, entered into by participating private, state, and federal groups should be an integral part of any logging program.

3. Stream clearance requirements, and their enforcement, are essential.
   (a) Every effort should be made to prevent logging debris from falling into stream channels. If any debris does get into a channel, it should be removed in order to maintain adequate dissolved oxygen levels in surface waters, provide access to spawning grounds for adults, and keep migration routes open for outmigrant juveniles.
   (b) The method of stream clearance and timing of the operation are also important. Heavy equipment should not normally be used in a stream, and the channel should not be altered. Consultation with the local State fishery biologist can aid in determining what material should be removed from a stream, and the best time for removal.

4. Streamside vegetation should be protected and remain standing in all logging operations where fish, wildlife, and water quality considerations are involved or can be affected in downstream areas.
   (a) Streamside vegetation provides shade to the stream and minimizes water temperature increases.
   (b) Commercial conifers do not necessarily have to be left. Shrubs and other less valuable species can, in many cases, provide adequate shade if the conifers can be removed without destroying such vegetation or damaging streambanks. In some areas, commercial timber may have to remain to protect other watershed values or await the technological development of other removal methods.
   (c) Areas of vegetation left along a stream do not have to be a certain width. Often a relatively narrow vegetative unit will provide the necessary fish habitat protection unless other factors such as wildlife habitat enhancement and scenic corridors are involved.

(d) Protecting streamside vegetation serves many purposes. Maintaining a vegetative unit requires care in falling and yarding timber away from the stream, and will reduce stream clearance needs and dissolved oxygen problems in surface and subgravel waters.

5. Avoid falling trees into or across streams.

6. Logs should not be yarded through streams.
   (a) Yarding logs through streams deposits organic and inorganic debris and sediment in the channel, breaks down streambanks and streamside vegetation, and contributes to dissolved oxygen and sediment changes in surface and subgravel environments.
   (b) Use yarding methods that minimize soil disturbance in the watershed.
   (c) Landings should not be located in the stream channel.
   (d) Logs should be yarded uphill and away from the stream.

The Society of American Foresters,[2] Columbia River Section, Water Management Committee[3] has developed a list of recommended logging practices for watershed protection in Western Oregon. The recommendations reflect concern for the impact of roads on stream sediment levels and emphasize proper road location, construction, and maintenance. Although available in the Journal of Forestry for more than ten years, many logging operations have not incorporated the practices into their programs. Therefore, in an attempt to get wider distribution of the Water Management Committee's suggested practices, most of its recommendations follow verbatim.

Road Location and Design

1. Where possible, locate roads on benches and ridges to minimize erosion; except under special circumstances such as occurrence of rock bluffs, keep roads out of stream courses. Roads should be high enough to prevent silting to the stream.

2. Keep road gradients low except where short, steep sections are needed to take advantage of favorable topography and to avoid excessive cut and fill. Minimize the effect of higher gradients by re-

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[2] Written permission to reprint this material has been granted by the editorial staff of the Journal of Forestry.

[3] A complete copy of the article and qualifying statements by the Committee is available in the Journal of Forestry, Vol. 57, No. 6, June, 1959. Portions of the article not included in this pamphlet relate to introductory statements, logging operations, and post-operational cleanup and maintenance. The Committee is currently revising and updating its recommendations, which will reflect increased concern about the effects of logging on fish habitat and water quality.

ducing the distance between culverts to prevent the accumulation of water in the ditches.

3. Roads leaving landings should have short lengths of slightly adverse grade if possible. They should not have steep pitches of favorable grade which might drain off mud from the landings into streams.
4. Allow flexibility in road design so that in construction a minimum of soil is moved. Adjust the radius of curves in critical areas to achieve this objective.
5. Take advantage of well-drained soils and horizontal rock formations for greater stability, and avoid areas where seeps, clay beds, concave slopes, alluvial fans, and steep dipping rock layers indicate the possibility of slides.
6. Consider the proper angle of repose for cuts and fills in designing roads on varying types of soils and rock materials. Consistent with these demands, make road cuts reasonably steep in order to minimize surface exposed to erosion.
7. In bridge location plan to avoid relocation of the stream channel. Where the stream must be changed,[4] use rip rap, vegetative cover, or other means to reduce soil movement into stream.
8. Install culverts at crossings of all drainage ways except small streams[5] and seeps which can be safely diverted to ditches. Use culverts with sufficient capacity to carry the largest flow expected.
9. Route the road drainage (whether from culverts, cross drainage, or ditches) onto the forest floor, preferably on benches so that sediment can settle out before drainage water reaches stream channels.
10. Take drainage water out of ditches at intervals short enough to prevent ditch erosion. Detour it from above, unstable areas to avoid saturation, slumping, and erosion.

Road Construction

1. Plan the pioneering stage of road construction to avoid soil erosion and slumpage. As an example, cull log crossings[6] can be provided where culverts will be placed on the completed road. Avoid pioneering too far ahead of final construction.

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[4] Timing of bridge construction and culvert installation is important. During the summer, streamflows are low and impacts on fishery resources can be minimal and localized. At that time migration of juveniles to the ocean and adults returning to spawn would thus not be disrupted. (Author's footnote.)

[5] Until recently the importance of small streams was not fully documented. Culverts should be installed on all small streams supporting anadromous fish. (Author's footnote.)

[6] Cull log crossings placed in a stream in the spring can eliminate the downstream migration of fingerlings to the ocean. (Author's footnote.)

2. Uncompleted road grades which may be subject to considerable washing before final grading should be out-sloped or cross-drained.

3. Hold wet-weather road building to a minimum, particularly on poorly drained, erodible soils which may drain mud directly to streams.

4. Build fills in lifts to insure optimum compaction and minimize slumpage. Avoid the inclusion of slash, logs, and other organic debris in fills.

5. Excess fill material should not be dumped within the high-water zone of streams where floods can pick it up or where it will flow immediately into the stream; end-haul such material.

6. Where slide areas can be predicted from past experience, their effects should be minimized by such measures as flatter back-slopes and deeper ditches. On slopes gentle enough to hold the fill, avoid disturbance of underground water courses by building on the fill and providing adequate sub-drainage.

7. On primary roads with steep slopes and full benching, consider the use of cribbing to avoid severe disturbance to unstable slopes.

8. On primary roads wherever serious erosion is likely, large cut-and-fill slopes should be stabilized with plant cover as soon as possible. Local experience will indicate the best practices and species to use.

9. Avoid channel changes or disturbance of stream channels. Where necessary complete the channel change and rip-rap the sides before turning water into the new channel.

10. In building bridge footings and abutments, limit machine work as much as possible to avoid disturbing the stream. This initial work often greatly increases turbidity and sediment movement. The toes of fills on larger creek crossings should be protected above the high-water line to prevent soil movement.

11. Unless no other source is available, gravel should not be taken from streambeds except from dry gravel bars.[7] Washing of gravel into streams will normally cause sedimentation and should be avoided.

12. Culverts should be properly installed in the stream channel allowing for suitable bed, adequate size, frequency, and grade.[8] Inlets and

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[7] A permit is now required to remove more than 50 yards of gravel from the bed or bank of any water in Oregon (O.R.S. 541.605 to 541.660). Permits are issued under the authority of the Director of the Division of State Lands and coordinated with a number of other state agencies. (Author's footnote.)

[8] Culvert gradient curves and stream velocity requirements for salmon and trout are available from the Oregon State Game Commission. (Author's footnote.)

outlets should be protected. Aprons should be installed where needed.

13. Where necessary, protect the upper ends of culverts to prevent fill erosion into them. On erodible soil materials, extend culverts beyond the fills or install permanent aprons below them to disperse flows and prevent gullying.

14. Ditches should be of adequate depth and side slope to carry all water and to prevent sloughage.

Road Maintenance

1. Keep roads well crowned ahead of wet weather so they will drain properly and not become waterways.

2. During current operations, roads should be graded and ditched to avoid interruption to drainage from road centers to the ditches.

3. After the first rain in the fall, check roads to reduce drainage problems.

4. During periods of heavy rainfall, examine road surfaces to assure that drainage from wheel ruts is properly diverted to drainage ditches. During such periods it may be worthwhile to provide personnel to patrol the roads and to do hand drainage work.

5. Provide frequent cross-drains on all temporary roads in the fall to prevent erosion of road and fill.

6. Generally, berms should be removed or at least broken frequently to allow lateral drainage to nonerodible areas. Berms are desirable on large erodible fills to prevent drainage from the road crown down the center of the fill section.

7. In using graders to clean out drainage ditches, avoid undercutting the side slopes.

8. Culvert inlets should be inspected and cleaned prior to the rainy season and periodically during that season. For at least 50 feet above culverts the stream channels should be cleared of wood materials that might clog the culverts. The outflow should be kept clear also.

9. Install trash racks well above inlets to culverts where experience shows the necessity. Keep the racks cleaned out.

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The concepts developed in this publication for the protection of fish habitat and water quality in logging operations are the result of findings from the Alsea watershed research program on the Oregon coast and related studies. The Alsea study was initiated in 1958 by the Governor's Committee on Natural Resources with the broad objectives of clarifying potential areas of conflict between two of Oregon's major resources, timber and fish, and of suggesting ways to eliminate conflicts. The research program has been a cooperative effort involving many agencies and individuals. Major cooperators include the Oregon Game Commission, Oregon State University's Department of Fisheries and Wildlife and School of Forestry, the U.S. Forest Service, Georgia-Pacific Corporation, the U.S. Geological Survey, Federal Water Quality Administration (now the Environmental Protection Agency), and the Bureau of Commercial Fisheries (now National Marine Fisheries Service).

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